Antenna Tuners: Are They Necessary?

Novice Notes:

- What does an antenna tuner do?
- What types of antenna tuners are available?
- Should I build or buy?

The short answer, as you may have guessed, is "sometimes." The longer—and more enlightening—answer follows.

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Antenna-matching networks are known by several names, but they all perform essentially the same kind of work: They enable you to match your feed line to your transmitter. For example, suppose your feed line presents a 100-Ω *impedance* to your 50-Ω transceiver.[1] In order to ensure maximum transfer of RF energy, you must match the unlike impedances. In some situations a matching network may be used to do this.

Another consideration is that the correct impedance be presented to the transmitter, because modern solid-state rigs have a built-in *SWR*-protection circuit. The higher the SWR (standing-wave ratio) the lower the transmitter output power. This circuit prevents the final-amplifier transistors from being destroyed (vacuum tubes are more tolerant of high SWR values).

When a tuner is used to match the transmitter output to a feed line, ARRL literature refers to the network as a *Transmatch*, for "transmitter match." It is important to note that a Transmatch does not correct a mismatch that may be present between the feed line and the antenna feed point.

What Does a Transmatch Do?

A high SWR is caused by a significant mismatch between the antenna and its feed line. Depending on the electrical length of the line, this mismatch may be reflected as a pure resistance, or as a resistance plus *reactance* at the line input. A Transmatch can cancel the reactance and make the antenna system appear resistive (ideal) at the rated impedance of the transmitter, normally 50 Ω.

Transmatches contain variable capacitors and coils (inductors). The coil may be tapped to permit band changing, or it may be a roller inductor with a counter dial. Roller inductors are most useful; they ensure continuously variable inductance. A tapped-coil inductor has only coarse-adjustment capability, so it may be impossible to match some impedances.

Fig 1A shows the circuit of a T-network Transmatch. This circuit (The Ultimate Transmatch) was popularized by Lew McCoy, W1ICP, in *QST*,[2] although that version uses a two-section variable capacitor at the input side of the network. Fig 1B shows a parallel-tuned Transmatch suitable for matching an unbalanced source to a load that has balanced feeders (50 Ω to 300 Ω, for example).

Most commercial tuners contain a version of the T network shown in Fig 1A. Some manufacturers include a *balun* (balanced to unbalanced) *transformer*—a broadband toroidal transformer that allows you to connect unbalanced coaxial cable to balanced feed line, such as 300-Ω ribbon or 450-Ω ladder line. The balun transformer can be useful under ideal matching condi-

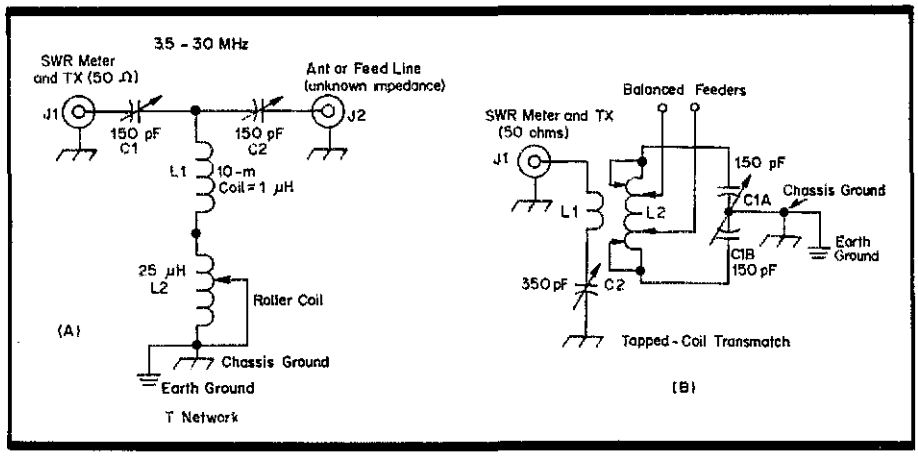

Fig 1—Circuit examples for Transmatches. The popular version at A is used by most manufacturers of commercial tuners. L1 is usually included to improve the circuit Q at 10 and 15 meters, because some roller inductors do not have a tapered coil pitch at one end of the inductor. Increasing the capacitance at C1 and C2 to 300 pF will enable the circuit to work at 1.8 MHz as well. Circuit B has a tapped coil. The outer taps are adjusted to change the coil inductance. The inner taps are moved equally from the ends of L2 to obtain a matched condition for balanced feed lines. C2 is adjusted along with C1 to obtain an SWR of 1:1. L1 is a small link over the center of L2. A single-wire antenna may also be tuned with this circuit by connecting it to one of the inner coil taps.

[1]Notes appear on page 44.

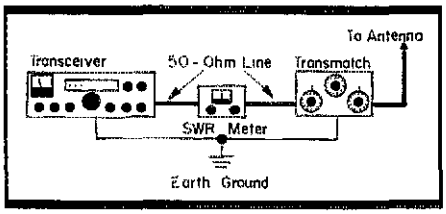

Fig 2—The correct way to connect a transceiver to an SWR indicator and Transmatch. Some Transmatches contain a built-in SWR meter. In this case the outboard SWR meter may be eliminated. Most commercial Transmatches are equipped with a built-in balun transformer to allow the use of balanced feed lines. Terminals for a balanced line are located on the rear apron of the tuner.

tions. The balanced Transmatch in Fig 1B is a better device for this job, however, as it can provide the desired match without a significant loss of power.

Any tuning network has an *insertion loss*, however minor. The addition of a balun transformer increases this loss.

Seeing SWR

An SWR meter enables us to observe the power reflected from the Transmatch back to the transmitter as we tune out the reactance in the antenna system. The lower the reactance, the lower the reflected-power reading. (Remember: The SWR in the line between the Transmatch and the antenna does not change.)

The SWR meter should have the same characteristic impedance as the coaxial feed line and transmitter output circuit. Typically, this is 50 Ω for RG-58, RG-8 and other 50- or 52-Ω cable. Don't use a 75-Ω SWR indicator in a 50-Ω line, or vice versa; it will provide inaccurate readings. Always locate the SWR meter between the transmitter output port and the input port of your Transmatch. Use 50-Ω coaxial cable to connect the unit to the transmitter and tuner.

How to Hook Up and Adjust Your Transmatch

A proper hookup for the SWR meter and Transmatch is shown in Fig 2. An effective earth ground should be attached to your transmitter and Transmatch. A short, heavy conductor (such as the shield braid from RG-8 coaxial cable) may be connected to a cold-water pipe—only if you have copper or galvanized steel plumbing.

If your plumbing uses PVC pipe (which is nonconductive), connect your station (again, using a short heavy conductor) to an 8-foot ground rod driven into the soil near your shack. If the cable between your equipment and the ground is more than a quarter-wavelength long or longer at your operating frequency, your ground may not function effectively, or may even be worse than no ground at all! (See December 1988 *QST*, page 57, and the sidebar, "What is a Counterpoise," on page 44 of November 1988 *QST*.)

Most commercial Transmatches have instructions, but for those who need them, generic instructions follow.

- Set the SWR meter function switch to REFLECTED or REF.
- Activate your transceiver and choose an operating frequency.
- Adjust the Transmatch controls while listening to your receiver. You will find settings that yield maximum background noise or signal response; these represent a coarse starting point for your Transmatch adjustments.
- Make sure the frequency for testing is not in use. Turn on the transmitter and allow a small amount of power (about 20 watts is okay) to pass to the Transmatch.
- Adjust the Transmatch controls until the SWR is 1:1 (zero reflected power).
- Adjust your transceiver for full power output and quickly readjust the Transmatch controls to correct for any residual SWR that may be indicated. Be sure to identify your station.

You are now ready to operate! Log the Transmatch dial settings so you can return to this frequency another time without needing to go through the tuning process.

When to Use a Transmatch

Many antennas are fed with 50-Ω coaxial line, and the SWR is low—less than, say, 2:1—across most of a given amateur band. There is no point in using a Transmatch in this situation. Most transmitters can handle an SWR that is 2:1 or lower. Dipole antennas, trap verticals and triband Yagis should not require a Transmatch if they are adjusted to the usual operating frequency and the feeder is matched correctly to the antenna feed point.

There are situations where a Transmatch is useful with a dipole, vertical or beam antenna. If the antenna has a low SWR at one end of a band (such as a tribander adjusted for the high end of a band), it may have a high SWR at the other end of that band. Your Transmatch may then be used to provide the desired 50-Ω interface to the antenna system. But this does not correct the mismatch at the antenna end of the line. It merely allows your transmitter to deliver its full power to the feed line.

End-fed wire antennas normally require a Transmatch, especially if you plan to use the wire for multiband operation. With this type of antenna, the feed impedance varies greatly from one amateur band to another.

Although they are simple to install, end-fed wires can cause problems, at least on some frequencies. Radio-frequency voltage is often brought into the ham shack because one end of the the antenna is connected to the Transmatch. This RF energy finds its way into keyers, antenna rotator control boxes and the audio (microphone) circuitry of our transceivers. This causes audio squeals and howls and can make a keyer send gibberish. You may also experience a tingling sensation when you touch your rig, microphone or key, caused by RF voltage on these items! The best way to avoid these problems is to use a coax-fed antenna, such as a dipole.

Glossary

Antenna tuner—A device that matches the output of a transmitter to its feed line.

Balun transformer—A device that matches a *bal*anced load *to an un*balanced line, or vice versa. Used when coaxial cable (unbalanced) is fed to a dipole antenna (balanced), for example.

Impedance—Total opposition to current flow, including reactance as well as resistance.

Insertion loss—The amount of power lost due to the addition of a network or circuit.

Reactance—Similar to resistance, and also measured in ohms. May be inductive (abbreviated X_L) or capacitive (X_C).

SWR—Standing-wave ratio: A measure of the power reflected back to the transmitter. The higher the SWR, the less power reaches the antenna.

Transmatch—Another name for antenna tuner.

Store Bought or Homemade?

Many amateurs build their Transmatches to save money and provide some workshop fun. Certainly a Transmatch is one of the least complicated home projects you can build! Be on the lookout for surplus variable capacitors and roller coils at flea markets and in parts catalogs. New parts for tuners may be purchased from RADIOKIT and Barry Electronics.[3,4] Transmatch circuits are published in *The ARRL Handbook* and *Antenna Book*.

Choose variable capacitors that have a wide spacing between the plates (1/16 inch or greater for 100-watt transmitters). This will help prevent arcing between the capacitor plates. The 200-pF preset variable capacitors from WW-II Command transmitters are excellent for Transmatch use at power levels below 200 watts.

In Summary

Operating with a 1:1 SWR is not a sacred mandate. No one will notice a difference in your signal strength if the SWR is 1:1 or 2:1, assuming your transmitter has some output-matching capability. The main consideration is that you keep your transmitter "happy" by providing it something near a 50-Ω load. There's no need to buy or build a Transmatch if you don't need one!

Notes

[1]Words that appear in italics are defined in the Glossary.

[2]"The Ultimate Transmatch," *QST*, July 1970, pp 24-27, 58.

[3]RADIOKIT, PO Box 973, Pelham, NH 03076, tel 603-437-2722.

[4]Barry Electronics, 512 Broadway, New York, NY 10012, tel 212-925-7000.